Air Quality Monitoring

Tolko Industries, High Prairie

December 2005 and March 2006 **Final Report**

Summary

An air quality survey was conducted near Tolko Industries, located west of High Prairie, about ½ km north of Hwy 2. Alberta Environment's mobile laboratory (MAML) monitored for various air pollutants downwind of Tolko Industries. In addition, air samples were also collected for analysis of a suite of volatile organic compounds (VOCs) including phenol and formaldehyde.

Instruments on-board the MAML monitored for ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide. Concentrations of hydrogen sulphide (H_2S) were below detection limit. The maximum one-hour average concentrations of particulate matter, carbon monoxide (CO) and oxides of nitrogen (NO_x) were measured concurrently. These concentrations were likely influenced by vehicle emissions on Hwy 2. Monitoring results indicate that elevated concentrations of particle bound polycyclic aromatic hydrocarbons (PAHs) had multiple sources, one of which is likely Tolko Industries. Where applicable one-hour concentrations did not exceed Alberta's Ambient Air Quality Objectives (AAAQO), the maximum one-hour concentrations were:

- 0.1% for the one-hour objectives for ammonia (NH_3)
- 11% for the one-hour objectives for nitrogen dioxide (NO_2)
- 45% for the one-hour objectives for ozone (O_3)
- 6% of the one-hour objectives for carbon monoxide (CO)
- 1% of the one-hour objectives for sulphur dioxide (SO_2)

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VOCs concentrations measured downwind of Tolko industries did not exceed established AAAQO and were notably lower than the known odour thresholds. The most abundant VOCs were butane, pentane, isopentane and benzene. Elevated concentrations of these VOCs were likely due to motor vehicle emissions on Hwy 2. Concentrations of phenol were found to be below detection limit (0.006 parts per million, ppm). Formaldehyde concentration of 0.001 ppm was measured downwind of Tolko Industries, however this concentration was comparable to that measured on the McIntyre Building roof in Edmonton (0.002 ppm).

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Introduction

As part of its air quality monitoring program, Alberta Environment conducts unannounced air quality surveys through out the province. Such a survey was conducted in the area of Tolko industries for two days in December of 2005 and two days in March of 2006. Tolko industries, located west of High Prairie, produces Oriented Strand Board (OSB) panels. OSB panels are produced from wood strands, flakes and wafers that are bonded using a synthetic resin. The process involves high temperature and pressure, during which pollutants may be released into the atmosphere; this would occur in addition to any fugitive emissions from the facility. The objectives of this study included the quantification of selected pollutants in the proximity of Tolko Industries and comparison of measured concentrations to Alberta's Ambient Air Quality Objectives.

Air quality surveys are typically performed using the Alberta Environment's mobile laboratory, MAML. The MAML provides an air quality "snap shot" in time and place. Pollutants monitored by instruments on-board the MAML are ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide. In addition to MAML measurements, samples were collected for analysis of volatile organic compounds (VOCs), with a special focus on formaldehyde and phenol. These two compounds were selected for monitoring because Tolko Industries uses phenol-formaldehyde synthetic resin in the production of OSB panel. In the following sections, monitoring locations and methods as well as results from the various measurements will be discussed.

Monitoring Methods and Locations

Ambient monitoring had four components: the MAML and three forms of VOCs sampling. The primary monitoring tool for special ambient air monitoring projects is the MAML; this holds true for the current study. Parameters monitored by the MAML include ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide. MAML monitoring was conducted on December 19th and 20th of 2005, and March 13th and 14th of 2006. Instruments on-board the MAML are automated and measure the concentrations of various pollutants simultaneously. On-board computer store one-minute averages; one-hour averages presented in this report were determined using these data. A total of 16 hours of MAML data was collected. MAML monitoring sites are indicated on Figure 1 and described in Table 1. MAML sampling was conducted downwind of Tolko Industries, either at **Site 1** (West of Tolko Industries) or **Site 2** (East of Tolko Industries) depending on the prominent wind direction. Every effort was made to monitor directly downwind of Tolko Industries. This being said, there were times when monitoring downwind was prevented by limited access. In such cases, the next best accessible location was used.

In addition to MAML monitoring, samples were also collected and analyzed for a suite of volatile organic compounds (VOCs). Stainless steel canisters were used to collect air samples at three locations (Figure 1; Table 1). A total of four samples were collected. Three samples were collected west (downwind) of Tolko Industries (two at **Site 1** and one at **Site 3**). One of these had a corresponding upwind sample. These samples were analyzed for eighty-three different VOCs. Analyses were performed at Alberta Research Council's environmental monitoring laboratory.

Phenol and formaldehyde are present in the synthetic resin used in OSB panel production. A separate set of samples were collected for the analysis of these two organic compounds. *Xposure Aldehyde Sampler®* was used to collect samples for formaldehyde analysis. The sampler consists of a sorbent cartridge. A sorbent tube (XAD-7 from SKC inc.) was used to sample phenol. In both cases a constant flow of air is pulled though the samplers using a pump. As air passes through the samplers, selected VOCs will sorb onto the inside surface of these samplers. At the end of the sampling period the cartridges/tubes were sealed and sent to the laboratory where extracts from the samplers were analyzed for formaldehyde or phenol,

depending on the sampler. In order to insure sufficient sample was collected for analysis, air was pulled though the samplers for about 4 hours. There were four samples taken, not including a sample for blank correction. Two samples were collected downwind of Tolko Industries (**Site 1** and **3**). The third sample was collected at **Site 4** about 500 meters northeast of Tolko Industries mill (**Site 4**). The fourth sample was a comparison sample collected on the roof of McIntyre building, in Edmonton. These samples were analyzed by EnviroTest laboratories in Edmonton.

Figure 1: MAML monitoring site[1]

Table 1: Description of monitoring sites

Site number	*Monitoring*	*Description*
1	MAML, Canister, Cartridge	West of Mill RR 181
2	MAML, Canister, Cartridge	East of Mill RR 180
3	MAML, Canister, Cartridge	RR 182 and north of Hwy 2
4	Cartridge	Containment hill (Berm)

Notes:

RR – Range road Hwy – Highway

[1] Base map from Atlas Canada: http://atlas.nrcan.gc.ca/site/index.html

Results and Discussion

A summary of MAML monitoring results and Alberta's Ambient Air Quality Objectives (**AAAQO**) for monitored pollutants are presented in Table 2. A discussion on AAAQO is given in Appendix B. The minimum, median and maximum values shown in Table 2 were calculated from one-hour average concentrations measured downwind of Tolko Industries. One-hour average concentrations are reported in Table A1 in Appendix A.

Total Hydrocarbons (THC)

Total hydrocarbons include a broad family of chemicals that contain hydrogen and carbon. Methane (CH_4) a non-reactive hydrocarbon is the most abundant of the hydrocarbons. In rural areas of Alberta, THC is almost entirely composed of CH_4 with a background concentration of about 2 parts per million (ppm). The remaining fraction of THC is referred to as Reactive hydrocarbons (RHC). The major sources of total hydrocarbons are fugitive emissions such as leaks and evaporations, vehicle emissions and vegetation.

A significant portion of the THC and CH_4 concentrations measured downwind of Tolko were equivalent to background levels. One-hour average THC concentrations ranged from 1.7 to 3.6 ppm, with 50% of the concentrations being equal to or lower than 2.0 ppm. Examination of the one-minute average data revealed that there was a gradual increase in THC concentrations, which was almost entirely CH_4 in composition. Other measured pollutants did not increase simultaneously. The maximum THC concentrations was observed when the wind speed was low (~1 km/hr) and the wind direction was variable. Concentrations measured at this time may have been impacted my emissions from the MAML generator. The MAML generator runs on natural gas and is equipped with a scrubber. However, during calm conditions CH_4 from the generator exhaust can interfere with THC measurements. A description of the MAML is given in Appendix B. Reactive hydrocarbons were above the detection for only one of the sixteen sample hours, at which time one-hour average was 0.1 ppm.

Sulphur compounds (Total Reduced Sulphur and Sulphur Dioxide)

Total reduced sulphur (TRS) includes hydrogen sulphide (H_2S) and other reduced sulphurs. Major industrial sources of TRS include natural gas and petrochemical plants, pulp

and paper mills and animal feedlots. Sulphur dioxide (SO_2) is not a reduced sulphur, thus not included in TRS. Sources of SO_2 include oil and gas processing, gas plant flares and pulp and paper mills.

Concentrations of sulphur compounds measured downwind of Tolko Industries were comparable to background levels. Concentrations of TRS downwind of Tolko were close to or below detection limit of the instrument on-board the MAML (0.6 parts per billion, ppb). One-hour average concentrations of the H_2S fraction of TRS were below detection limit (0.6 parts per billion, ppb). The maximum one-hour concentration of 0.001 ppm downwind of Tolko was equivalent to the median value for the rural air quality station at FortMcKay (Table 3). Similarly, SO_2 concentrations downwind of Tolko industries were low. The maximum one-hour average concentration of 0.002 ppm was 1% of Alberta's ambient air quality objective.

Oxides of Nitrogen and Carbon Monoxide

Oxides of nitrogen (NO_x) is the sum of nitrogen dioxide (NO_2) and nitric oxide (NO). In Alberta, transportation is the major source of NO_x. NO is typically associated with relatively fresh emissions, NO_2 is formed as NO reacts with ozone. Carbon monoxide (CO) typically has the same source as NO_x, it is introduced into the atmosphere primarily though incomplete combustion.

The maximum one-hour average NO_x and CO measured downwind of Tolko Industries were somewhat elevated for a rural environment. The one-hour average NO_x concentrations ranged from 0.002 ppm to 0.046 ppm. The one-hour average concentrations for CO ranged from below detection limit and 0.8 ppm. The highest concentrations for both NO_x and CO were observed during the same hour. At this time, a significant fraction (63%) of NO_x was composed of NO, indicating relatively fresh emissions. The maximum NO_2 concentration of 0.023 ppm was 11% of AAAQO, thus there were no exceedance. The predominant wind direction was south of south west (SSW), this implies that samples during this hour likely had contributions from vehicle emissions on Hwy 2, about 1 km south of **Site 1** (Figure 1).

Particulate Matter (PM) and Polycyclic Aromatic Hydrocarbons (PAHs)

Particulate matter less than 10 micrometer (μm) in aerodynamic diameter (PM_{10}) are the fraction of particles that can be inhaled into the mouth and nose. Particulate matter less than

2.5 μm in aerodynamic diameter ($PM_{2.5}$) are small enough to be respired into the lungs. Total suspended particulate (TSP) includes both PM_{10} and $PM_{2.5}$, typically the diameter for TSP is less than 500 μm. Polycyclic aromatic hydrocarbons (PAHs) may be found in the gaseous form or bound onto particles. The instrument on-board the MAML monitors particulate bound PAHs. PAHs typically occur in complex mixtures and have varying levels of toxicity. Sources of particulate matter include dust (agriculture, road, soil), smoke and vehicle exhaust, and PAHs arise from incomplete combustion.

The median one-hour averages for particulate matter indicate that overall, concentrations were low. The median one-hour average concentration for TSP, PM_{10} and $PM_{2.5}$ were 18, 12 and 3 $\mu g/m^3$, respectively. These concentrations were among the lowest measured for recent MAML surveys (Table 3). This being said, relatively high maximum one-hour averages indicate that at times particulate concentration at the site can be elevated. The maximum one-hour concentrations of 289 $\mu g/m^3$ (TSP), 198 $\mu g/m^3$ (PM_{10}) and 21 $\mu g/m^3$ ($PM_{2.5}$) were observed concurrently with the maximum NOx and CO one-hour average concentrations. This implies that elevated particulate concentrations were likely due to vehicle exhaust (see section on NO_x and CO) . Furthermore, one-hour average PAHs concentration at this time was second highest measured for the study (13 ng/m^3), supporting a combustion source.

The median one-hour average concentration of 2 ng/m^3 shows that PAHs concentration overall were comparable to background concentration (typically 1 ng/m^3 or lower). The maximum one-hour average of 14 ng/m^3 was measured when the MAML was located directly downwind of Tolko Industries (Easterly winds, Table A1 and A2). Examination of the one-minute average data illustrated that PAHs concentrations were elevated throughout the whole hour; furthermore, the MAML operator noted sweet odour (Table A2). These observations indicate that the vehicle emissions were not the only PAHs source in the area, emissions from Tolko Industries likely contributed.

Table 2: Summary of one-hour average concentrations determined using data collected by instrumentation on-board the MAML.

Pollutant	Unit	AAAOQ	Minimum	Median	Maximum
CO	ppm	13.0	bd	0.2	0.8
O_3	ppm	0.082	0.001	0.018	0.037
THC	ppm	n/a	1.7	2.0	3.6
CH_4	ppm	n/a	1.8	1.9	3.6
RHC	ppm	n/a	bd	bd	0.1
SO_2	ppm	0.172	bd	0.001	0.002
NO	ppm	n/a	bd	0.006	0.029
NO_2	ppm	0.212	0.001	0.005	0.023
NO_x	ppm	n/a	0.002	0.011	0.046
NH_3	ppm	2.0	bd	bd	0.002
TRS	ppm	n/a	bd	0.001	0.001
H_2S	ppm	0.010	bd	bd	bd
TSP	$\mu g/m^3$	n/a	5	18	289
PM_{10}	$\mu g/m^3$	n/a	4	12	198
$PM_{2.5}$	$\mu g/m^3$	n/a	1	3	21
PAHs	ng/m^3	n/a	bd	2	14

Notes:

ppm - parts per million **ng/m³** = nanograms per cubic metre **µg/m³** = micrograms per cubic metre

bd - below detection limit of analyzer (Table B2 in the Appendix B) **n/a** - not available

Phenol and Formaldehyde

Tolko Industries uses synthetic (phenol-formaldehyde) resin in its OSB production. During the production year of 2005, the facility reported on-site emission of 65 tonnes of formaldehyde[2]; it was the substance with the highest reported air release for 2005. As a result, the current study included monitoring of formaldehyde and phenol downwind of Tolko Industries. In addition, samples were also taken upwind and at a comparison site. Samples for formaldehyde analysis were collected using aldehyde sampler cartridge. Samples for phenol analysis were collected using sorbent sample tubes. The section on sampling methods and locations gives a description of sampling methods.

Formaldehyde and phenol concentrations are reported in Table 4. Phenol concentrations were below the detection limit at all the sites. Phenol detection limit for the sampling conditions

[2] Air releases: 2005 NPRI found at http://www.ec.gc.ca/pdb/npri/npri_online_data_e.cfm

used for this study was 0.006 ppm. Downwind of Tolko Industries, formaldehyde concentration of 0.001 ppm was measured. This concentration was comparable to concentration measured at the McIntyre building (Edmonton). Formaldehyde concentration at this comparison site was 0.002 ppm. Concentrations at all other sites were below detection limit. Formaldehyde detection limit for the sampling conditions used for this study was 0.001 ppm. Phenol and formaldehyde concentrations were sampled for about 4 hours; concentrations determined are an average for this period. As a result, reported concentrations cannot be directly compared to the one-hour AAAQOs. Alberta has a one-hour objective of 0.053 ppm for formaldehyde and of 0.026 ppm for phenol.

Table 3: Median one-hour average concentrations for selected MAML surveys and permanent monitoring stations.

Station or Survey Type	Air Quality Station or Survey Name	Monitoring Period	CO ppm	O_3 ppm	THC ppm	CH_4 ppm	RHC ppm	SO_2 ppm	NO_2 ppm	NH_3 ppm	TRS ppm	H_2S ppm	TSP $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PAH ng/m^3
mobile	Tolko (current study)	Dec 2005 -Mar 2006	0.2	0.018	2.0	1.9	bd	0.001	0.005	bd	0.001	bd	18	12	3	2.4
	Caroline [1]	Oct 05 & Jan, May, Jun 06	0.2	0.038	1.8	1.8	bd	0.002	0.004	0.003	0.001	0.001	79	49	6	1
	Girouxville[1]	Fall 2004, spring 2005, 2006	0.3	0.028	2.1	2.1	bd	0.001	0.001	0.013	0.002	0.001	21	15	2	bd
	Whitecourt[1]	Sep. 6 - 7, 2005	0.2	0.027	2.1	2.1	bd	0.001	0.002	0.084	0.001	0.001	28	16	2	1
Permanent Continuous Monitoring Stations																
urban	Calgary Central[2]	Dec 05 - Mar 06	0.5	0.009	2.1	n/a	n/a	n/a	0.030	n/a	n/a	n/a	n/a	21	5	n/a
	Edmonton Central[2]	Dec 05 - Mar 06	0.4	0.008	2.2	n/a	n/a	n/a	0.027	n/a	n/a	n/a	n/a	n/a	5	n/a
Rural	Fort Chipewyan[3]	Dec 05 - Mar 06	n/a	ND	n/a	n/a	n/a	bd	bd	n/a	n/a	n/a	n/a	n/a	2	n/a
	Fort McKay[3]	Dec 05 - Mar 06	n/a	ND	2.1	n/a	n/a	0.001	0.006	n/a	0.001	n/a	n/a	n/a	2.9	n/a
Industrial	Mannix[3]	Dec 05 - Mar 06	n/a	n/a	2.1	n/a	n/a	0.001	n/a	n/a	n/a	bd	n/a	n/a	n/a	n/a
	Mildred Lake[3]	Dec 05 - Mar 06	n/a	n/a	1.9	n/a	n/a	0.001	n/a	n/a	n/a	bd	n/a	n/a	n/a	n/a

Notes:

ppm – parts per million **$\mu g/m^3$** – micrograms per meter cubed **ng/m^3** – nanograms per meter cubed

bd – below detection limit **n/a** – parameter not monitored or data not available **ND** – no data

1 – Mobile survey conducted by Alberta Environment.

2 – Station operated by Alberta Environment.

3 – Station operated Airsheds.

Table 4: Phenol and formaldehyde concentration downwind of Tolko mill and comparison sites.

Date	Sampling Time	Sampling Location	Phenol ppm	Formaldehyde ppm	Operator Comments
Dec 19/05	15:52 to 20:12	West side of Tolko mill Range Road 181	bd	***0.001***	
Dec 19/05	16:12 to 20:03	Range Road 182, 400m North of Hwy 2	bd	bd	Moved 800m North at 18:00
Dec 20/05	09:05 to 13:00	NE corner of Tolko Mill	bd	bd	Upwind
Dec 20/05	10:51	Range Road 181	bd	bd	Blank
Dec 22/05	09:02 to 13:22	McIntyre Roof	bd	***0.002***	
Mar 13/06	16:44 to 20:45	3 km south of Hwy 2 on Ranged Road 180	bd	bd	
Mar 14/06	8:39 to 12:38	Range Road 180 approx 1.2 km North of Hwy 2	bd	bd	Overcast, light snow
Mar 14/06	9:46 to 13:40	Range Road 175 0.4 km North of Hwy 2	bd	bd	Overcast -18C slight odours

Notes:

ppm - parts per million **bd** – below detection limit of analyzer (for the sampling conditions during this study detection limit was 0.006ppm for phenol and 0.001 for formaldehyde)

Volatile Organic Compounds (VOCs)

Volatile Organic Compounds (VOCs) include a large group of chemicals containing carbon and hydrogen. The more reactive VOCs can readily react with nitrogen oxide in the presence of sunlight to produce a number of secondary compounds including ground level ozone. Ozone is a contributor to smog and a health hazard. At elevated concentrations some VOCs can also have adverse affect on health and vegetation. This section discusses the results from canister air samples.

A total of five samples were collected for VOCs analysis. Table 5 summarizes VOCs concentrations that were above detection limit. Also indicated in Table 5 are one-hour AAAQOs. Alberta does not have ambient objectives for all the VOCs measured. In addition to ambient objectives, concentrations were also compared to odour thresholds. As is evident in Table 5, VOCs concentrations were significantly lower than the odour thresholds and did not exceed established one-hour AAAQO. A complete suite of VOCs analyzed are listed in Table A3.

The most abundant VOC for all the samples was butane, with concentrations ranging from 4.4 to 6.7 $\mu g/m^3$. Concentrations of pentane, benzene and isopentane were also relatively elevated. Concentration differences between samples collected at **Site 1** (west of Tolko) and **Site 2** (east of Tolko) were not significant. The predominant wind direction during the time of sample was from the southeast, putting **Site 1** upwind and **Site 2** downwind of Tolko industries. The total VOCs concentration at **Site 1** was 27.8 $\mu g/m^3$; in comparison total VOCs concentration at **Site 2** was 23.4 $\mu g/m^3$. Had Tolko industries been the main contributor of VOCs at **Site 1,** a notable difference between these two sites would have been apparent. The lack of significant difference in the VOCs concentrations between samples taken up and downwind of Tolko Industries implies other sources. VOCs typically assigned as biogenic such as α and β pinene were detectable downwind of the Tolko Industries (**Site 1**) but were below detection limit at **Site 2**. These VOCs may have originated from the mill during drying or handing processes.

The sample with the lowest concentrations was taken downwind of the log pile west of Tolko industries (**Site 1a**). Wind direction at the time of sample was easterly eliminating possible contributions from vehicle emissions on Hwy 2. For this sample, concentrations of butane, ispentane, hexane, pentane and toluene were lower than sample 1 at **Site 1** and sample 3

at **Site 2** (Table 5). These VOCs possibly originated from vehicle emissions. Although the overall VOCs concentration at **Site 1a** was low, concentrations for a number of VOCs were above the detection limit. Measurable VOCs concentration in the sample taken at **Site 1a** may be due to background levels and/or emissions from Tolko industries. The current survey is unable to decipher between the two possible sources.

Table 5: Summary of VOCs concentrations that were found to be above detection limit.

Site	1	1a	2	3	AAAQO	Odour Threshold	
Sample	1*	2	3*	4			
Start time	19 Dec 2005 16:29	20 Dec 2005 10:46	19 Dec 2005 16:22	19 Dec 2005 18:10	1-hour	Low	High
Description	West of Mill	Log pile	~ 1km East of Mill	0.4 north of Hwy 2			
	1936	1925	1931	2137			
Units	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	
2,3-Dimethylbutane	bd	0.468	bd	bd			
2-Methylhexane	0.360	0.471	0.204	bd			
2-Methylpentane	1.072	bd	0.805	0.731			
2-Propanone	0.868	0.543	0.571	bd			
3-Methylhexane	0.348	bd	0.307	0.241			
3-Methylpentane	0.545	0.207	0.447	0.366			
alpha Pinene	0.439	bd	bd	bd			
Benzene	2.908	2.497	2.679	2.704	30	4,500	270,000
beta Pinene	0.578	bd	bd	bd			
Butane	6.711	4.387	6.355	5.620		2,850	14,630
cis-1,2-Dichloroethylene	0.202	bd	0.246	0.218			
Cyclohexane	0.282	bd	0.333	0.230		1,435	
Ethylbenzene	0.225	bd	0.152	bd	2,000	8,700	870,000
Freon-11	0.745	0.706	0.756	0.695		28,000	1,170,400
Freon-12	0.613	0.505	0.524	0.534			
Heptane	0.327	bd	bd	0.200		200,000	1,280,000
Hexane	1.181	0.594	1.009	0.883		77,141	
Isobutane	1.748	1.207	1.703	1.563			
Isopentane	2.520	1.263	2.037	1.872			
m,p-Xylene	0.290	bd	0.199	bd	2,300	348	174,000
Methylcyclohexane	0.349	0.130	0.365	0.304		2,000,000	
Methylcyclopentane	0.343	0.003	0.285	0.216			
Methylene chloride	0.003	bd	0.003	0.003			
o-Xylene	0.199	bd	0.134	bd		3,693	
Pentane	3.621	2.181	3.267	3.179		6,600	3,000,000
Toluene	1.087	0.384	0.726	0.557	1,880	8,025	150,000
Trichloroethylene	0.278	bd	0.273	0.177			
Total VOCs	***27.843***	***15.546***	***23.381***	***20.293***	--	--	--

Notes:

µg/m³ - micrograms per cubic metre **bd** – below detection limit

* - These samples were taken a approximately the same time upwind and downwind from Tolko Industries

**- 5% match quality: match quality indicates the confidence level at which the compound has been identified

Intentionally Blank

Appendix A

Table A1: One-hour average concentrations measured downwind of Tolko Industries.

Sample Date	End Times	CO PPM	O_3 PPM	THC PPM	CH_4 PPM	RHC PPM	SO_2 PPM	NO PPM	NO_2 PPM	NO_x PPM	NH_3 PPM	TRS PPM	H_2S PPM	TSP $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	PAH ng/m^3
12/19/2005	12:51 to 13:59	0.3	0.008	2.7	2.6	bd	bd	0.004	0.006	0.011	0.001	bd	bd	16	9	2	2
12/19/2005	15:35 to 16:35	0.3	0.005	2.8	2.9	bd	bd	0.014	0.011	0.024	0.001	0.001	bd	124	70	8	14
12/19/2005	16:35 to 17:35	0.2	0.002	2.4	2.4	bd	bd	0.010	0.013	0.022	bd	0.001	bd	235	150	14	8
12/19/2005	17:35 to 18:35	0.8	0.001	2.7	2.7	bd	0.001	0.029	0.018	0.046	0.001	0.001	bd	289	198	21	13
12/19/2005	18:35 to 19:35	0.7	0.004	3.2	3.2	bd	0.001	0.007	0.011	0.017	0.001	0.001	bd	179	104	9	3
12/19/2005	19:35 to 20:35	0.6	0.006	3.6	3.6	bd	0.001	0.007	0.009	0.015	bd	0.001	bd	92	59	7	2
12/20/2005	10:01 to 11:01	0.1	nd	2.4	2.5	bd	bd	0.002	0.004	0.006	bd	bd	bd	18	12	3	1
12/20/2005	11:01 to 12:01	0.1	0.006	2.4	2.4	bd	bd	0.002	0.003	0.005	bd	bd	bd	15	11	2	3
3/13/2006	15:43 to 16:33	0.2	0.037	1.8	1.8	bd	0.002	0.006	0.005	0.011	bd	bd	bd	13	9	2	1
3/13/2006	17:30 to 18:31	0.2	0.023	1.8	1.8	bd	0.002	0.016	0.021	0.037	0.002	0.001	bd	197	95	10	9
3/13/2006	18:31 to 19:35	0.2	0.020	2.0	1.9	0.1	0.001	0.010	0.023	0.033	0.001	0.001	bd	133	78	11	7
3/14/2006	08:37 to 09:37	0.1	0.017	1.8	1.8	bd	0.001	0.005	0.003	0.009	bd	0.001	bd	17	10	3	2
3/14/2006	09:37 to 10:37	0.1	0.018	1.8	1.8	bd	0.001	0.001	0.001	0.002	bd	0.001	bd	5	4	1	1
3/14/2006	10:37 to 11:37	bd	0.018	1.7	1.8	bd	0.001	0.000	0.001	0.002	bd	bd	bd	7	5	1	1
3/14/2006	11:37 to 12:37	bd	0.018	1.8	1.8	bd	0.001	0.002	0.001	0.003	bd	bd	bd	7	4	1	1
3/14/2006	12:37 to 13:37	bd	0.021	1.7	1.8	bd	0.001	0.001	0.001	0.002	bd	0.001	bd	6	4	1	bd

NOTES:

ppm - parts per million **ng/m^3** = nanograms per cubic metre **$\mu g/m^3$** = micrograms per cubic meter **bd** – below detection limit of analyzer **nd** – not determined

Table A2: Meteorological conditions and operator's comments

Sample Date	End Times	Temp Deg C	RH %	WSP KPH	WDR DEG	Operator's comments
12/19/2005	12:51 to 13:59	-2.3	72.0	4.9	204	
12/19/2005	15:35 to 16:35	-7.8	86.6	6.2	92	
12/19/2005	16:35 to 17:35	-9.8	94.6	4.9	130	
12/19/2005	17:35 to 18:35	-10.9	96.6	2.9	207	
12/19/2005	18:35 to 19:35	-11.5	98.0	3.3	117	
12/19/2005	19:35 to 20:35	-11.7	97.2	3.7	130	
12/20/2005	10:01 to 11:01	-13.0	91.2	3.7	61	RR 181 on west of log pile
12/20/2005	11:01 to 12:01	-11.5	90.5	3.9	85	
3/13/2006	15:43 to 16:33	-3.2	54.5	6.7	295	RR 180 north of Hwy 2, very slight occasional odour
3/13/2006	17:30 to 18:31	-7.5	67.9	5.2	280	On Hwy 2 approx 1/2 mile SE of mill; plume going overhead most of the time
3/13/2006	18:31 to 19:35	-10.1	76.9	4.5	274	Dust due to mill operations
3/14/2006	08:37 to 09:37	-17.4	78.3	11.0	256	Some odours as plume goes overhead
3/14/2006	09:37 to 10:37	-16.1	71.9	8.6	257	RR 180 ~1.5 km North of Hwy 2
3/14/2006	10:37 to 11:37	-15.9	70.4	10.4	243	0.8 km east of mill
3/14/2006	11:37 to 12:37	-15.0	65.3	9.0	263	0.8 km east of mill
3/14/2006	12:37 to 13:37	-13.8	62.5	8.6	259	0.8 km east of mill

NOTES:
Temp - Temperature in degrees centigrade
RH - Relative humidity in percentage
WSP KPH - Wind speed in Km/hr
WDR DEG - Wind direction in degrees
RR - Range Road **Hwy** - Highway

Table A3: Canister air samples were analyzed for the following list of VOCs. Concentrations of VOCs above the detection limit are shown in Table 5.

1,1,1-Trichloroethane	Chloromethane
1,1,2,2-Tetrachloroethane	cis-1,2-Dichloroethylene
1,1,2-Trichloroethane	cis-1,3-Dichloropropylene
1,1-Dichloroethane	cis-2-Butene
1,1-Dichloroethylene	cis-2-Hexene
1,2,4-Trichlorobenzene	cis-2-Pentene
1,2,4-Trimethylbenzene	Cyclohexane
1,2-Dibromoethane	Cyclopentane
1,2-Dichlorobenzene	Cyclopentene
1,2-Dichloroethane	Ethyl benzene
1,2-Dichloropropane	Freon-11
1,3,5-Trimethylbenzene	Freon-113
1,3-Dichlorobenzene	Freon-114
1,4-Dichlorobenzene	Freon-12
1-Butene	Heptane
1-Pentene	Hexachlorobutadiene
2,2,4-Trimethylpentane	Hexane
2,2-Dimethylbutane	Isobutane
2,3,4-Trimethylpentane	Isopentane
2,3-Dimethylbutane	Isoprene
2,3-Dimethylpentane	Isopropylbenzene
2,4-Dimethylpentane	m,p-Xylene
2-Methyl-1-pentene	Methylcyclohexane
2-Methyl-2-butene	Methylcyclopentane
2-Methylheptane	Methylene chloride
2-Methylhexane	Nonane
2-Methylpentane	n-Propylbenzene
3-Methyl-1-butene	Octane
3-Methylheptane	o-Xylene
3-Methylhexane	Pentane
3-Methylpentane	Styrene
4-Methyl-1-pentene	Tetrachloroethylene
Alpha-Pinene	Toluene
Benzene	trans-1,2-Dichloroethylene
Beta-Pinene	trans-1,3-Dichloropropylene
Bromomethane	trans-2-Butene
Butane	trans-2-Hexene
Carbon tetrachloride	trans-2-Pentene
Chlorobenzene	Trichloroethylene
Chloroethane	Vinyl chloride
Chloroform	

Appendix B

Alberta's Ambient Air Quality Objectives

Alberta's Ambient Air Quality Objectives[1] are established under Section 14 of the Environmental Protection and Enhancement Act (EPEA , R.S.A. 2000, c.E-12, as amended). EPEA provides for the development of environmental objectives for Alberta.
The Ambient Air Quality Objectives are used for:

- Reporting on the state of the atmospheric environment in Alberta.
- Reporting to Albertans on the quality of the air through Alberta's Air Quality Index (AQI).
- Establishing approval conditions for regulated industrial facilities.
- Evaluating proposals to construct facilities that will have air emissions.
- Guiding special ambient air quality surveys.
- Assessing compliance near major industrial air emission sources.

Some of Alberta's Ambient Air Quality Objectives are based on odour perception. This is the case for ammonia, nitrogen dioxide and hydrogen sulphide. For these chemicals, people are likely to detect an odour at concentrations well below levels that may affect human health. Alberta's Ambient Air Quality Objectives for one-hour average concentration of pollutants monitored by the MAML are listed in Table B1.

Table B1: Alberta's Ambient Air Quality Objective measured by the MAML

Pollutant	One-hour AAAQO (ppm*)	Basis for Objective
Ammonia	2	odour perception
Carbon monoxide	13	oxygen carrying capacity of blood
Nitrogen dioxide	0.212	odour perception
Ozone	0.082	reduction of lung function and effects on vegetation
Hydrogen sulphide	0.01	odour perception
Sulphur dioxide	0.172	pulmonary function

* parts per billion

[1] *Alberta Ambient Air Quality Objectives*. Alberta Environment. April 2005.

The Mobile Air Monitoring Laboratory (MAML)

The MAML is a 27-foot (8.2 m) vehicle that has been specially designed and equipped to measure air quality. It houses a variety of instruments that continuously sample the air at specified time or distance intervals. The MAML is equipped with:

- a dual computer system custom-programmed to accept and record the measurement of air samples from each analyser,
- a GPS (Global Positioning System) that identifies the MAML's location as it moves around Alberta,
- an exhaust purifying system that minimizes emissions from the vehicle and
- two on-board generators that are also equipped with exhaust scrubbers

Table B2 lists the pollutants and meteorological data monitored by the MAML. Also indicated are the lower and upper detection limits for each monitored species.

Figure B1: Alberta Environment's Mobile Air Monitoring Laboratory

Table B2: Pollutants and meteorological data monitoring by the MAML.

Pollutant	Operating Range	
	Lower Detection Limit*	**Upper Detection Limit****
Ammonia **(NH_3)**	0.001 ppm	5 ppm
Ozone **(O_3)**	0.001 ppm	0.5 ppm
Carbon Monoxide **(CO)**	0.1 ppm	50 ppm
Hydrocarbons		
Methane **(CH_4)**	0.1 ppm	20 ppm
Reactive Hydrocarbons **(RHC)**	0.1 ppm	20 ppm
Total Hydrocarbons **(THC)**	0.1 ppm	20 ppm
Polycyclic Aromatic Hydrocarbons **(PAH)**	3 ng/m^3	1000 ng/m^3
Oxides of nitrogen		
Nitrogen dioxide **(NO_2)**	0.0006 ppm	1 ppm
Nitric Oxide **(NO)**	0.0006 ppm	1 ppm
Oxides of nitrogen **(NO_x)**	0.0006 ppm	1 ppm
Particulate Matter		
Total Suspended Particulates **(TSP)**	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <10µm **(PM_{10})**	1 $\mu g/m^3$	1.0 g/m^3
Particulate Matter <2.5µm **($PM_{2.5}$)**	1 $\mu g/m^3$	1.0 g/m^3
Sulphur Compounds		
Hydrogen Sulphide **(H_2S)**	0.001 ppm	1 ppm
Total Reduced Sulphur **(TRS)**	0.001 ppm	1 ppm
Sulphur Dioxide **(SO_2)**	0.001 ppm	2 ppm
Meteorological data		
Wind Speed	0 km/hr	200 km/hr
Wind Direction	0 degrees	360 degrees
Temperature	-40 °C	50 °C
Relative humidity	0%	100%

ppm - parts per million

ng/m^3 = nanograms per cubic meter

$\mu g/m^3$ = micrograms per cubic meter

g/m^3 = grams per cubic meter

* The ***lower detection limit*** indicates the *minimum* amount of pollutant and the lower limit of meteorological data can be measured by the instrument.

** The ***upper detection limit*** indicates the *maximum* amount of pollutant the instrument can detect and the upper limit for meteorological data measured. This limit is set to provide the optimum precision over that range. The upper limit can be raised, however, precision at the lower levels (where most levels are monitored) is then compromised.